NEURAL NETWORK-BASED PROCUREMENT MODE SELECTION OF MRO MATERIALS

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Abstract: Maintenance, Repair and operations (MRO) have following features: large sum of types, relatively low requirement, and high transition cost. It costs companies a lot of money and human resource on MRO procurement. In order to make MRO procurement more efficient and scientific, this paper compared the cost of two MRO supply chain modes to get a scope for each mode. And then SOM neural networks method can be used to cluster the materials. Different types of materials take advantage of different procurement mode.

1 INTRODUCTION

MRO is abbreviation of Maintenance Repair and Operation, namely maintaining, repairing and operating materials and it's also called indirect materials. This kind of materials includes spare parts, machines, tools and consumables. Every company needs certain kinds of MRO materials to maintain their operation and business normally.

Because of the lots of kinds and specifications of MRO materials and relatively small demand, MRO materials procurement will inevitably lead to higher transaction costs. According to the survey (Wencheng Liu, 2008) , every industrial enterprise has large sum of MRO suppliers, resulting in inefficient MRO materials procurement, purchasing value of total purchases accounted for only 8% of enterprises, but it consumes more than 60% of purchasing resources. Steve Stall (2003) mentioned that MRO managers have come to realize that success is no longer measured through meeting production goals alone. They must now consider that every purchase and maintenance decision has a direct impact on their company's profit margin - as well as their own department's measurement of success. So you can see it is different from the direct procurement of MRO materials, which involves not only the normal production of enterprises, but also take up a large number of enterprises of human and financial resources. Therefore to strengthen the management of MRO materials, procurement is very important.

MRO study abroad is earlier, and the study focused on e-procurement. Cade Metz (2000), Jerry Goldstein (2001), Emily Kay (2001), Abbas ForoughiMehmet C. Kocakülah (2003) mentioned that MRO e-procurement can save time, improves efficiency and reduces paper work. The domestic study started from 2006. On the mode of procurement of MRO materials, MRO materials procurement study focused on the integration of mode-based, Minjie Wu (2007) proposed integration of the domestic industrial enterprises in international MRO procurement. Kongji Li, Yue Li (2009) proposed centralized procurement by the integration of procurement service providers. Si Chen (2010) mentioned that third party logistics providers undertake procurement, sales and logistics role of MRO supply chain to achieve integrated supply and demand. But Xiaoyu Xu, Daoli Zhu (2001) thought small and medium company can only take MRO procurement market mode.

The earliest scholars believed that MRO material should be obtained through the market, but in recent years, scholars have generally agreed that MRO materials procurement should be integrated. However, the literatures in these two modes are not theoretical or mathematical in-depth analysis to

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clarify the scope of these two modes. According to large sum of types and specifications of MRO materials, taking all the materials the same mode is not economic, so this paper is on the basis of previous research, in-depth comparative analysis of the two modes to propose the scope of the different mode and provide the basis of procurement channel for choosing.

2 ANALYSIS OF PROCUREMENT MODES

There are two supply chain modes of procurement, which are “manufacturers - companies” and “manufacturer - distributor - companies “. For the bulk procurement of raw materials, companies usually select the "manufacturers - companies" procurement mode. But according to MRO materials’ special feature of variety of types and specifications, if only selecting one of these two modes, will inevitably result in uneconomical MRO procurement management, So companies should analyze and compare of the scopes of these two modes, and then take a different mode to meet different types of MRO materials’ requirements.

2.1 “Manufacturers - Companies” Mode

"Manufacturers - companies” mode refers that enterprises (the ultimate consumers) procure materials from the manufacturer directly in commerce flow. In logistics, MRO materials are sent directly from the manufacturer to the enterprises (the ultimate consumer).

The cost of this mode as following：

Assumption：

y_1 ——Total cost of procurement in this mode，n ——Number of manufacturers，c_i ——Manufacturing cost，r_i ——Manufacturer’s profits，t_i ——Transaction costs.

Total cost of procurement in this mode as following：

$$y_1 = \sum_{i=1}^{n} (c_i + r_i + t_i)$$

2.2 “Manufacturers - Distributors – Companies” Mode

"Manufacturers - Distributors - Companies” mode refers that companies (the ultimate consumer) procure a variety of MRO materials from a distributor in commerce flow. In logistics, MRO materials are sent from the distributor (namely integrated MRO materials distributor, such as Grainger, Yao Shun and other companies) directly to the company (the ultimate consumer).

The cost of this mode as following：

Assumption：

y_2 ——Total cost of procurement in this mode，m ——Number of manufacturers，$m < n$，c_i ——Manufacturing cost，r_i ——Manufacturer’s profits，t_i ——Transaction costs，s_i ——Distributor’s profits.

Total cost of procurement in this mode as following：

$$y_2 = \sum_{i=1}^{n} (c_i + r_i) + \sum_{i=1}^{m} (t_i + s_i)$$

2.3 Modes Comparison

The difference between the two modes’ cost can be used to illustrate which mode is more economic. Namely,

$$y_1 - y_2 = \sum_{i=1}^{n} t_i - \sum_{i=1}^{m} (t_i + s_i)$$

Assumption：

$$Q_1 = \sum_{i=1}^{n} t_i \quad ,$$

$$Q_2 = \sum_{i=1}^{m} (t_i + s_i) \quad ,$$

The functions of Q_1 and Q_2 are shown in figure 1. In figure 1, q_0 is the intersection of Q_1 and Q_2, when $q < q_0$, companies should select the "Manufacturers - Distributors - Companies” mode. When $q > q_0$, companies should select the "Manufacturers - Companies” mode.

So the function of cost when companies combine the two modes is ABC in Figure 2. If the enterprise fails to combine the two modes, while using only one mode, the average cost function is $\overline{Q}$. Obviously, combining the two modes can cut cost and the cost saving is in the area of the shaded in figure 2.

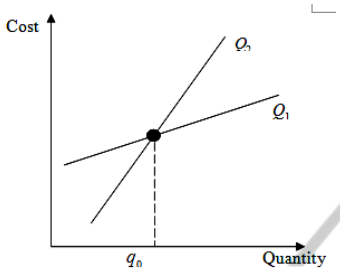

Figure 1: Cost Functions of Two Modes.

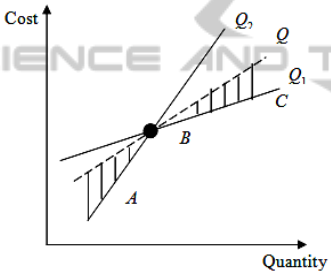

Figure 2: Cost Savings.

3 SELECTION OF PROCUREMENT MODES

3.1 Theoretical Methods

In reality, transaction costs, the profits of the manufacturers and distributors are hard to be separated. So direct calculating of the cost of the two modes is hardly realized. For this reason, here are trying to analyze the causes of cost to find the obvious characteristics of different modes, so that companies can use the scientific method to classify MRO materials according to these characteristics. It can easily and accurately identify different types of MRO procurement mode to be applied.

In figure 3, the intersection of the functions depends on purchasing quantity, which is to say the choice of procurement mode is depends on purchasing quantity. As MRO material has the characteristics of demand uncertainty, so enterprises generally sign a certain time frame contract of the total procurement quantity of one year to the supplier, which is the annual procurement volume. Annual procurement volume is equal to material's value multiple quantity. Therefore, the product of number and value of the purchasing material decides the enterprise's MRO procurement mode.

The number of materials' value and quantity can be classified by large, medium and small categories, so that there are nine situations of the product, see Table 1:

P represents the value of materials; Q represents the number of procurement; A represents large number; B represents medium number and C represents small number.

Table 1: Nine situations.

	P_A	P_B	P_C
Q_A	$P_A \times Q_A$	$P_B \times Q_A$	$P_C \times Q_A$
Q_B	$P_A \times Q_B$	$P_B \times Q_B$	$P_C \times Q_B$
Q_C	$P_A \times Q_C$	$P_C \times Q_C$	$P_C \times Q_C$

In order to achieve optimal benefit, companies should choose a suitable procurement strategy for each case in Table 1. Nine cases in Table 1 can be divided into three categories, namely the different three patents in Table 1:

① Gray Area

Gray area is on behalf of the large quantity of procurement or high value materials. It is very easy to be hand-selected in practice. The product is large obviously. So in this case, companies should select the "manufacturers - companies" mode.

② Slash Area

Slash area is on behalf of the small quantity and value of material purchasing. It's also very easy to be hand-selected in practice. The product is small obviously. So in this case, companies should select "Manufacturers - Distributors - Companies" mode.

③ White Area

White area is on behalf of the medium or small quantity or value. Because there are many kinds of MRO materials and the demand relatively less, so in manual work, a lot of material will be fall into this category. And this kind of materials do not have a typical product (relative maximum or relative minimum), it is difficult to determine the procurement mode by people.

In summary, the theoretical method is using quantity and value of procurement as a characteristic mark to select the MRO materials procurement

mode. However, in many cases, the feature can not be man-made classified (cases in white area), requiring a scientific and effective method to replace the manual classification.

3.2 Actual Operation Method

In order to solve the above-mentioned problem that artificially cannot be classified, this paper chooses neural network of self-organizing feature mapping network (SOM) algorithm for classification. The SOM algorithm provides an effective way and general framework for this type of problem, and it is a kind of advanced artificially intelligent algorithm.

Self-organizing feature map (SOM, Self - Organizing Feature Map) is also called the Kohonen network, which is put forward by the Dutch scholar Teuvo Kohonen in 1981. Kohonen think that a neural network will be divided into different regions when accept outside input mode, and each region has a different input mode response characteristics and this process is done automatically. Therefore, SOM network is widely used for clustering research.

Based on the analysis of procurement, MRO materials procurement model selection should be based on the annual purchasing quantity Q_n and value of the procurement for clustering. In this paper, we choose the plotsom neural network function in the Matlab to implement clustering, and the learning rate and other variables will use the default values in Matlab.

4 CONCLUSIONS

This paper focus on the characteristics of MRO, that the material type specification is so much while purchase quantity relatively small, by comparing the cost structure of the two modes of MRO materials' supply chain, the scope of application of these two types are obtained, and use the purchase quantity and value as characteristic value, we know that different kinds of materials should choose different purchase mode. In order to put the theory into practice, this paper use SOM neural network classification of MRO materials, to solve the problem that can't solve manually, and select different purchase model for different types of MRO materials, which make the procurement of MRO more efficiently. In this paper, the annual purchase quantity and the value are used as the characteristic value to establish the model. The method is simple, convenient and feasible and provides an effective way for enterprises to select the MRO materials procurement model.

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